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Particulate Control Mobile Test Units Third Year's Operation

Monsanto Research Corp, Dayton, Ohio

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Particulate Control Mobile Test Units: Third Year's Operation

Interagency Energy/Environment R&D Program Report

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ABSTRACT

This report summarizes the third year of operation for EPA-owned mobile test units. Unlike prior reports[1,2], detailed field test results are not included.

Three field units (baghouse, wet scrubber, and electrostatic precipitator) are designed to be used for studying the applicability of different methods for controlling fine particulate emitted from a wide variety of sources. A fourth unit (Energy Van) is designed to demonstrate the feasibility of unconventional energy supply systems to support residential and commercial buildings.

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SECTION 1

INTRODUCTION AND OBJECTIVES

The purpose of EPA Contract No. 68-02-1816 is to provide the operational effort required to obtain field laboratory and pilot plant test data from EPA-owned equipment and systems. Contract operations are divided into four areas:

MOBILE TEST UNITS

Mobile test units on the contract consist of truck-mounted items of conventional dust collection equipment: fabric filter, venturi scrubber, sieve tray scrubber, and electrostatic precipitator. Program objective is to assess the ease/difficulty in controlling particulate-laden gas streams by these items of equipment.

AERODYNAMIC TEST CHAMBER

This wind-tunnel-like chamber provides for gas movement in a wide range of velocities at temperatures from ambient to above 149°C (300°F) and accommodates a broad spectrum of gas composition and particulate loading. The test chamber is used primarily for calibration and testing of fine particulate measurement equipment and as a dust source for the mobile field units.

PILOT SO_x SCRUBBERS

Twin 23-cm (9-inch) diameter glass column scrubbers and associated support equipment comprise this pilot unit. Objectives are to determine quick, easy, inexpensive solutions to operating and technical problems encountered in the development of full-size SO_x scrubbing systems.

ENERGY VAN

The EPA Energy Van is a towable mobile home containing an energy supply system that utilizes environmentally clean and energy-conserving components. These components include fuel cells, a solar energy collector, a heat pump, and catalytic appliances. The objective of the mobile system is to develop and demonstrate an energy supply system for residential and commercial buildings which could cut pollution and energy consumption by as much as 50%.

The aerodynamic test chamber and pilot scrubber system are permanent installations at the National Environmental Research Center (NERC) in Research Triangle Park, North Carolina. Although the truck-mounted units use this location as a service base, the majority of their operating time is spent in the field at various plant sites throughout the country. The energy van is currently located at the NERC for performance testing.

The four operational areas represent, to varying degrees, different program interests and groups or sections within the Industrial Environmental Research Laboratory. The contractor's objective is to fulfill the needs of each interest within the contract scope. Thus, the level of involvement varies in each operational area. For example, in the areas of the aerodynamic test chamber and pilot SO_x scrubbers, the activities of program and test planning and interpretation of results are primarily conducted by EPA

personnel. In the mobile test unti area, however, the contractor is also largely responsible for developing the test plans and interpreting results obtained.

This report primarily summarizes activities of the mobile bag-house, wet scrubbers, electrostatic precipitator and energy van during the third contract year.

SECTION 2

REVIEW OF OPERATIONS

BAGHOUSE UNIT

Background

The mobile fabric filter system (baghouse unit) was designed and fabricated by GCA/Technology Division, Bedford, Massachusetts. The unit was mounted on a 1.36-metric-ton (1½-ton) truck and is described at length in GCA reports. Briefly, it has the following capabilities:

- Filtration can be conducted at cloth velocities as high as 0.102 m/s (20 fpm) with a pressure differential up to 4.98 kPa (20 in. water) and at a gas temperature up to 288°C (550°F).

- The mobile system is adaptable to cleaning by mechanical shaking, pulse jet, or low pressure reverse flow, with cleaning parameters which vary over broad ranges.

- The system can be operated in a series filtration mode.

- One to seven filter bags of any medium, 1.22 m to 3.05 m (4 ft to 10 ft) long and up to 0.3 m (12 in.) in diameter, can be used.

- Automatic instruments and controls enable 24-hour operation of the system.

After brief field tests, the unit was delivered to contractor personnel for use in a field testing program for the Industrial Environmental Research Laboratory of EPA.

For several reasons, the baghouse unit, as received, required preliminary "dry run" testing at the RTP Environmental Research Center, and intensive shakedown tests in the field under severe conditions. The dry run tests at RTP were directed at operational checks of system components and training of new operators.

The unit was then given shakedown tests in the field on a pulp mill lime recovery kiln. After a brief return to RTP for refurbishing, the unit was taken to Sunbury, Pennsylvania for tests on Pennsylvania Power and Light Company's Shamokin Dam, coal-fired generating station on 16 December 1974. These tests lasted through 26 February 1975.

On completion of these tests, about two months were required to refurbish the unit and sample trains, after which the unit was placed at a lime recovery kiln at Weyerhauser Corporation's pulp mill in Plymouth, North Carolina from 21 April 1975 to 19 September 1975.

After conclusion of testing at the Weyerhauser pulp mill, the baghouse was returned to Research Triangle Park, North Carolina for a complete repackaging and refurbishing effort.

As received, the baghouse unit was mounted in a 1.36-metric-ton (1.5-ton), stake bed truck. Portions of the system were relocated for operation outside the truck bed due to the truck size. This mode of operation turned out to be extremely inconvenient and detrimental to efficient field testing. Therefore, it was decided to mount the entire baghouse system in a 12.2-m (40-ft) tractor trailer unit.

The trailer unit was purchased and delivered on 30 January 1976, and repackaging commenced. In addition to transfer of the system to the trailer, potential solutions to a number of operational problems encountered during field operations were incorporated. Figures 1 and 2 show the current baghouse unit.

Third Year Testing

Completion of the repackaging effort was accomplished in August 1976 and the unit was taken to the field during the first half of November for tests on a refuse processing plant in St. Louis, Missouri.

St. Louis Testing

A baghouse field test was conducted 8 through 11 November 1976 at the city of St. Louis refuse processing plant. The baghouse was fed with a slip-stream installed on the plant's air density separator (ADS) cyclone exhaust duct. Pulse jet cleaning and felted Dacron polyester bags were used. Data were gathered on baghouse operation, inlet and outlet particulates mass, and inlet and outlet particle size.

Slipstream flow rate was 3.11-3.26 actual m^3/m (110-115 acfm) with a bag air-to-cloth ratio of 1.43-1.49 m/m (4.7-4.9 fpm). Bag cleaning was a problem due to the linty character of the plant's emissions. During operation, increased bridging between the bags was experienced. Changing cleaning interval and pulse duration did not improve cleaning. This observation suggests that the felted bags, bag spacing, and/or pulse cleaning may not be appropriate for the material from this source.

All individual samples on the baghouse inlet were invalid due to sample nozzle plugging. Inlet mass concentration was derived from the baghouse material collected and averaged 3.47 g/dsm^3

Figure 1. Current baghouse enclosure.

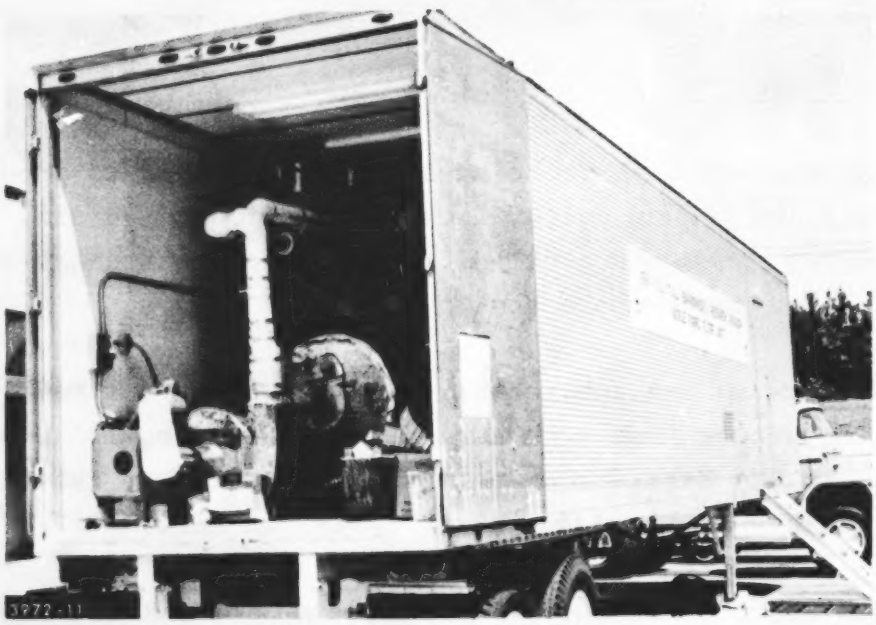

Figure 2. End view - baghouse.

(0.13 grain/dscf) over the three days in which outlet sampling was conducted. Extremely low baghouse outlet particulate concentration forced outlet samples to be extended over three days of operation. The measured outlet total mass concentration was 1.79×10^{-3} g/dsm^3 (6.7×10^{-5} grains/dscf). The resulting mass penetration was 0.05% (99.95% efficiency). Outlet particle size measurements showed 80% of the outlet mass smaller than 8 μm aerodynamic diameter (assuming 1 g/cc particle density) and a mass median diameter of 4 μm.

Baghouse fractional efficiency was estimated using previous particle size measurements by Midwest Research Institute on the ADS cyclone exhaust duct. The results indicate a bimodal fractional efficiency curve between 1 and 20 μm. The penetration reaches a maximum of 2% between 3 and 4 μm aerodynamic diameter; this size range represents less than 1% of the total inlet mass.

The unit performed exceptionally well in its first field test and was returned to Research Triangle Park for reconditioning and storage for the next field test.

Amarillo, Texas Test

Low sulfur western coal is being increasingly used to produce electricity and reduce sulfur dioxide emissions. Burning this coal, however, presents problems in applying electrostatic precipitators for particulate control.

To gather data on the applicability of baghouses for removing the particulate matter from such an installation, the mobile baghouse was taken to the Harrington Station of Southwestern Public Service Company (SPSCo), Amarillo, Texas, in April 1977.

Harrington Station has one 265 MW unit on-line burning low sulfur Wyoming coal. Objectives of the test were to obtain baghouse

operating data and information as well as particle collection capabilities on total mass and different particle sizes. Testing was conducted over a three-month period.

Total particulate mass sampling was conducted at the inlet and outlet of the baghouse. Both teflon/glass and graphite/glass bags were tested in two different cleaning modes -- reverse air and shake. Average total mass removal efficiencies were as shown in Table 1. Inlet concentrations generally increased with increasing boiler load, but the data showed no clear correlation. For all bag types, mass penetration decreased with increasing inlet mass concentration.

TABLE 1. TOTAL MASS REMOVAL EFFICIENCIES

Bag type	Cleaning mode	Removal efficiency, %
Teflon/glass	shake	99.83
Teflon/glass	reverse air	99.90
graphite/glass	shake	99.96
graphite/glass	reverse air	99.97

The graphite/glass bags performed better under test conditions than the teflon/glass in either cleaning mode.

Inertial cascade impactors were employed for particle size determinations. Brinks® impactors were used for inlet size distributions and Anderson® impactors for outlet size distributions. Figure 3 shows mass penetration versus particle size curves developed from averages of several size distribution measurements conducted. All four penetration curves shown exhibit minima. All curves show increasing penetration with decreasing particle size below 2 μm.

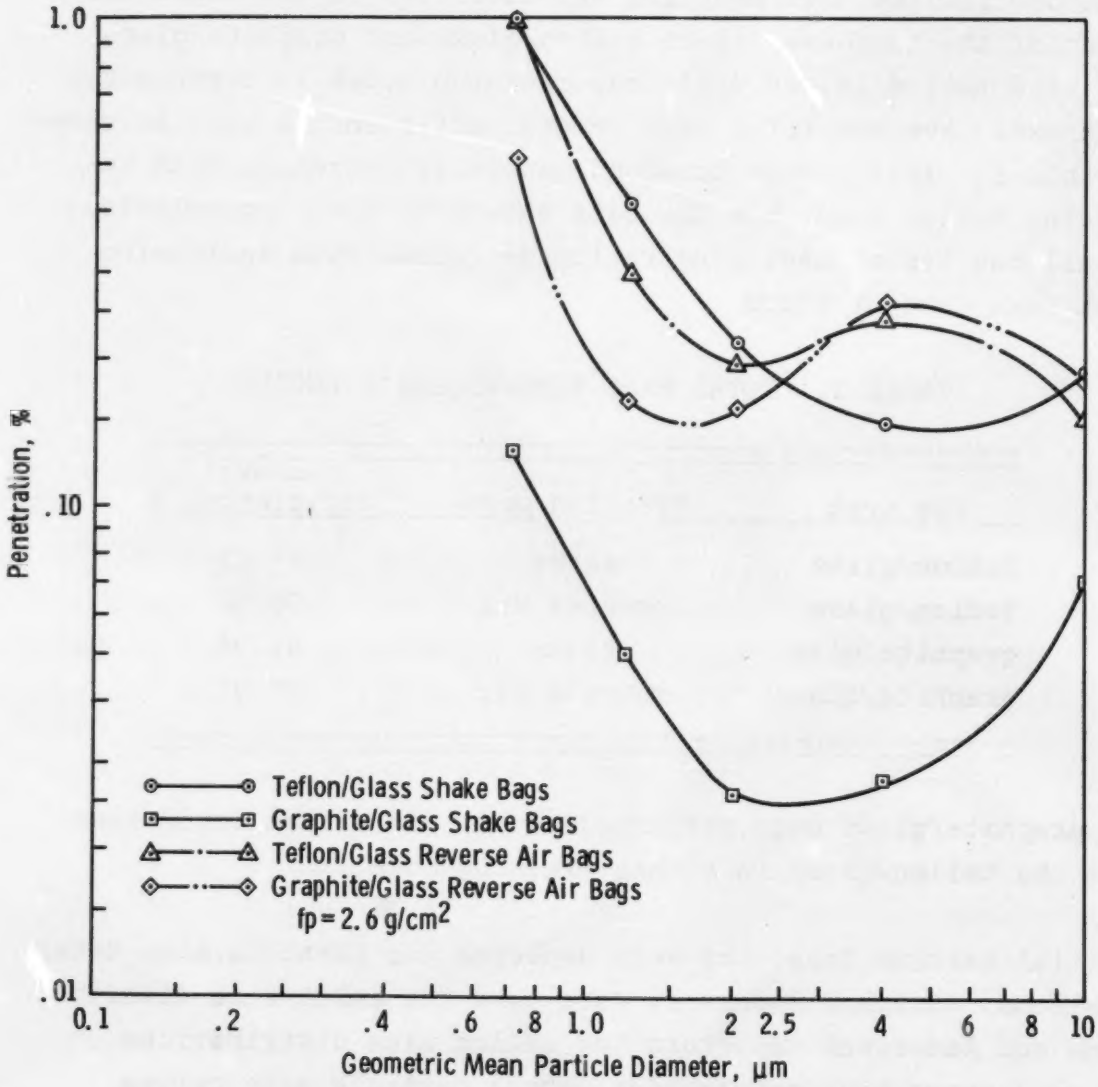

Figure 3. Average mass penetration vs geometric mean particle diameter.

The graphite/glass shake mode bags had the lowest penetration in the particle size range measured. Minimum penetration was 0.025%, 83% lower than the minimum for the teflon/glass shake mode bags.

Current Status

After the Amarillo test was completed, the baghouse was returned to base and awaits field assignment at this writing.

MOBILE SCRUBBER UNIT

Background

The mobile scrubber unit was designed and fabricated by the Detection Branch, Chemical and Biological Sciences Division of the Naval Surface Weapons Center (NSWC), Dahlgren, Virginia, under project order No. 4-0105-(NOL)/EPA-1AG-133(D), Task 2. On completion of construction and brief equipment checkout by NSWC, the unit was received by the Industrial Environmental Research Laboratory on 16 December 1974. The unit was subsequently placed on site at Pennsylvania Power & Light Company's generating station at Sunbury, Pennsylvania on 15 January 1975, for initial field shakedown testing. Shortly after startup of the unit at Sunbury, the induction fans failed and NSWC retrieved the unit to determine the cause of failure and repair the fans.

After completion of repairs and minor modifications, the unit was returned to IERL and taken to Research Triangle Park for extensive shakedown tests under simulated field conditions. It was then taken to Weyerhauser Corporation's pulp mill at Plymouth, North Carolina on 21 April 1975 and hooked up to a lime recovery kiln for execution of a test plan for evaluating dust control efficiency of the two types of scrubbers involved (venturi and sieve tray). Before a week of operation under field conditions was completed, the induction fans failed once more.

After the fans had failed for the second time, the scrubber unit was returned to Research Triangle Park, North Carolina for modifications. New fans of a different design were selected, purchased and installed in the scrubber unit. These items were received from the vendor during January 1976.

Carryover liquid had also been noted as an operational problem with the scrubber system, and the decision was made to replace the mist eliminator with another unit of different design to try and minimize this occurrence.

A third bothersome operational problem involved activation of automatic shutdown sequence due to false signaling from the sump tank overflow protection system. The cause turned out to be entrained mist. This problem was remedied by design change.

After the new equipment had been installed, the scrubber unit was subjected to simulated field testing at Research Triangle Park for two weeks. No problems surfaced during the testing, and a concerted effort was then initiated to find a suitable testing site.

In mid-June 1976, arrangements were finalized to place the scrubber on stream at a gray iron foundry. Testing was conducted over a two-month period at the iron foundry, and the unit was then returned to Research Triangle Park, North Carolina where it is in storage at this writing. Figures 4, 5, and 6 illustrate the scrubber unit configuration.

Iron Foundry Testing

While field testing at the iron foundry was completed by September 1976, urgent priorities have prevented test evaluation and reduction to reportable form over the period covered by this report. Such information will likely be summarized in the fourth annual operations report.

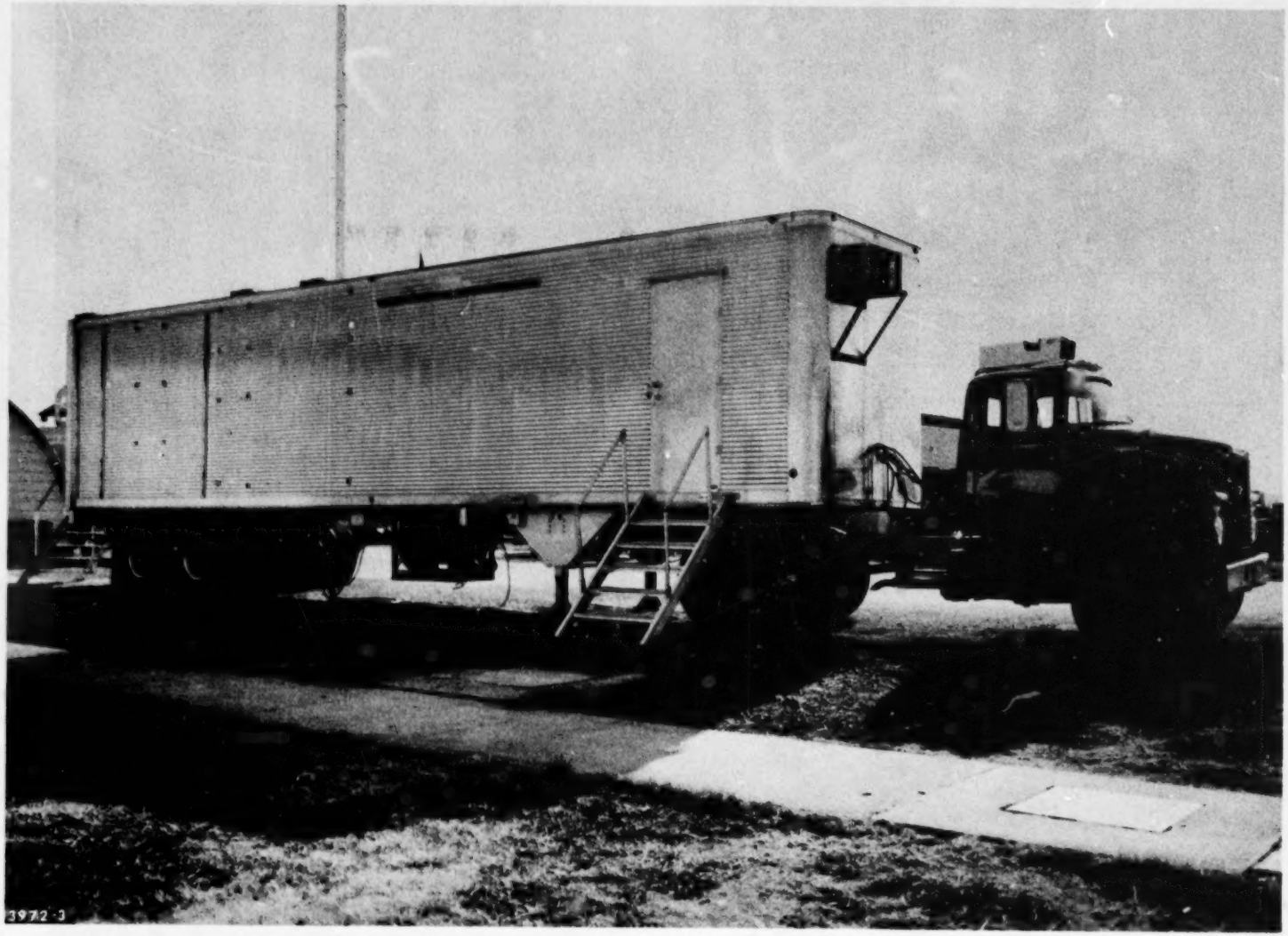

Figure 4. External view of mobile scrubber unit.

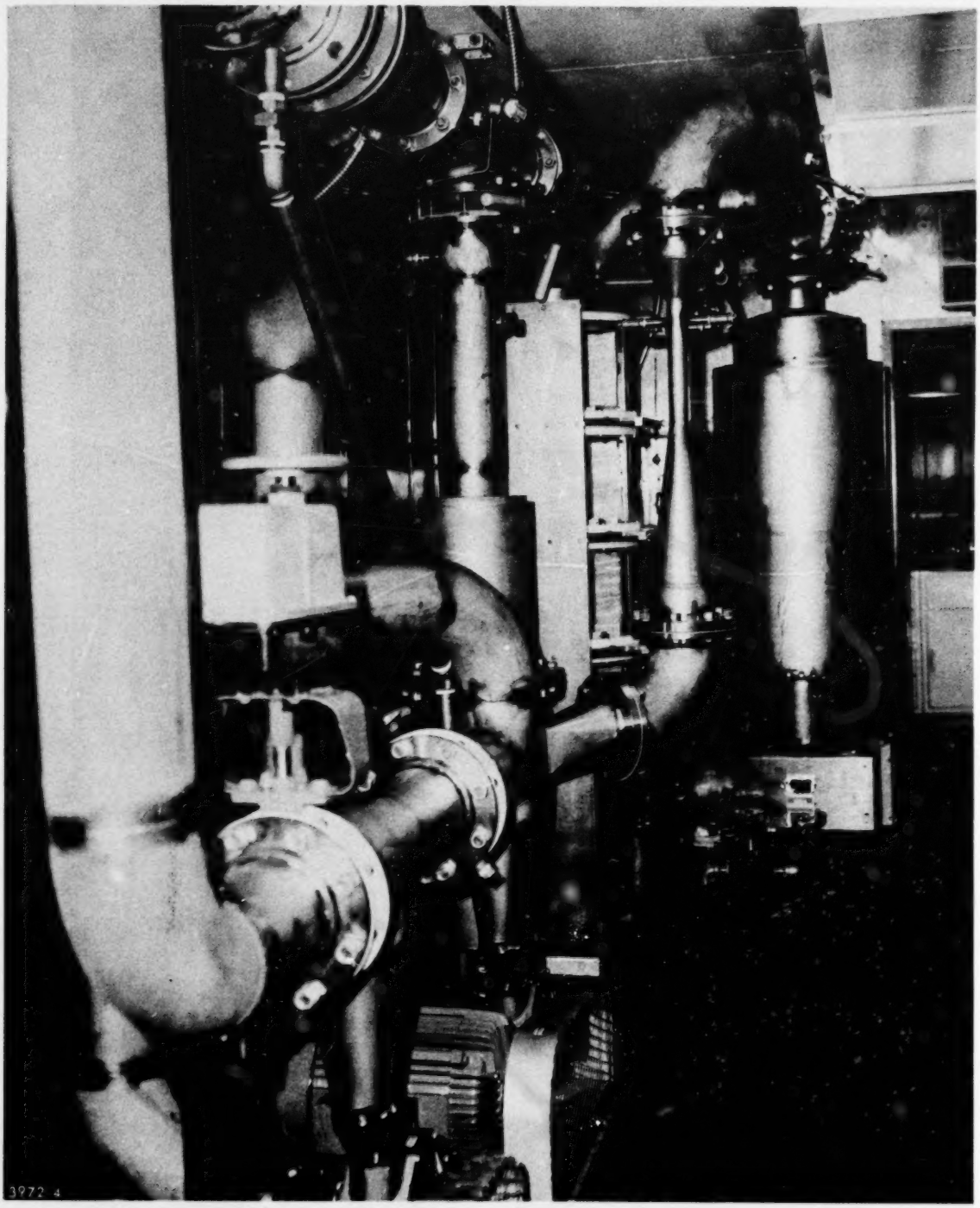

Figure 5. Mobile scrubber unit process area.

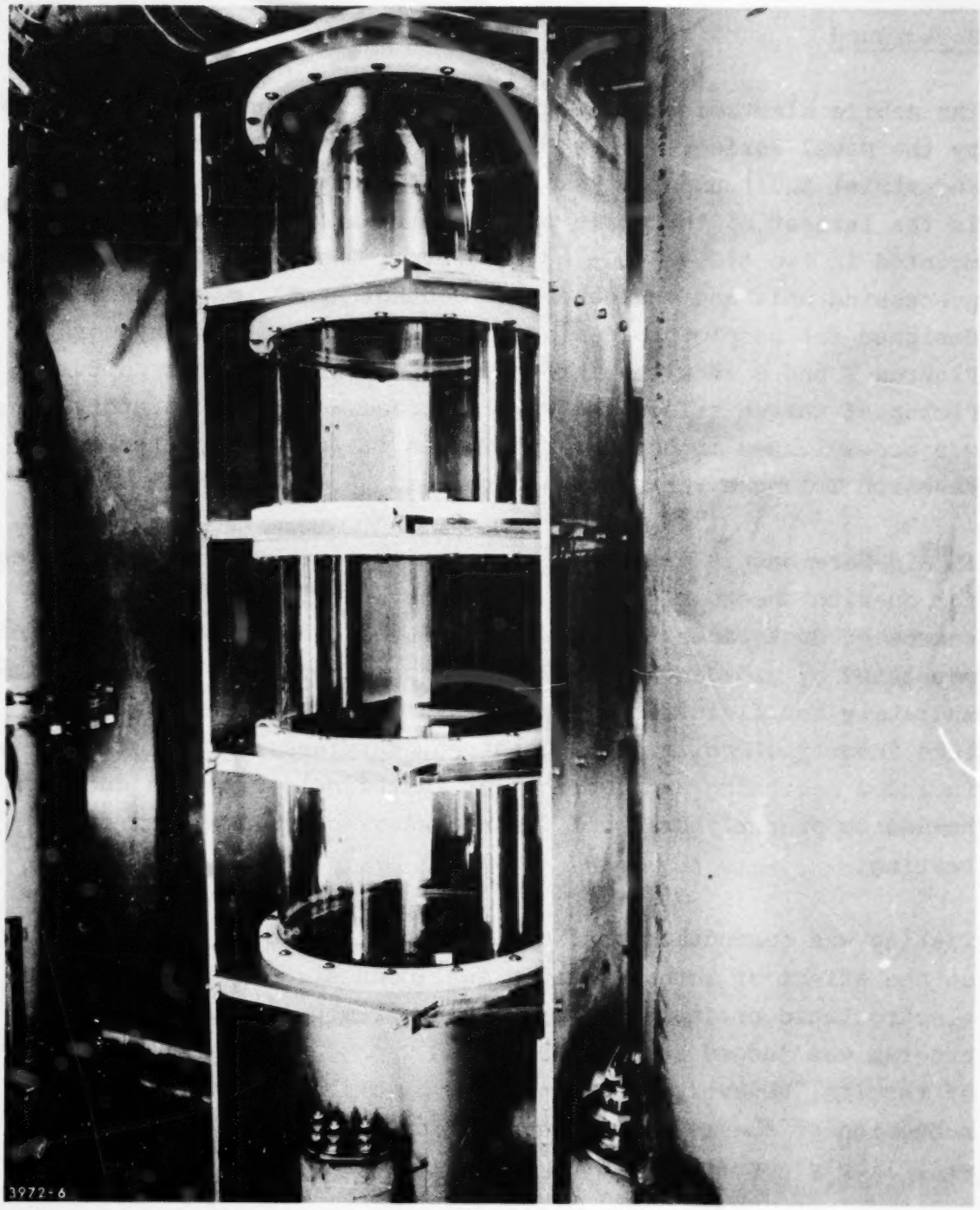

Figure 6. Sieve tray column.

MOBILE ELECTROSTATIC PRECIPITATOR

Background

The mobile electrostatic precipitator was designed and fabricated by the Naval Surface Weapons Center, Dahlgren, Virginia for the Industrial Environmental Research Laboratory of EPA. This unit is the largest of the three mobile pilot-scale units and is mounted in two 3.05-m (40-ft) trailers. One trailer contains the processing unit and the other the control panel, plus an area designed for sample processing and associated laboratory work. Figures 7 and 8 show the interior and exterior of this unit. Pickup of the unit from the Naval Surface Weapons Laboratory was accomplished in October 1976, when it was transported to Research Triangle Park, North Carolina.

In mid-December 1976, the electrostatic precipitator was prepared for on-site checkout testing using the EPA wind tunnel as a source of dust-laden test gas. These shake-down operations were completed by mid-January 1977 and preparations were initiated immediately for field testing on a refuse-derived fuel/coal mixed feed industrial boiler at Hagerstown, Maryland. Preparations included designing and fabricating additional inlet gas ductwork needed to properly draw off the necessary gas slipstream for testing.

Testing was conducted for two weeks in Maryland to gather data on the effect of refuse-derived fuel combustion product dust on electrostatic precipitator particulate removal efficiency. The program was judged successful, based upon a preliminary evaluation of results; however, other sampling priorities have prevented reduction of the results to report form to date. Such results will likely appear in the next annual report.

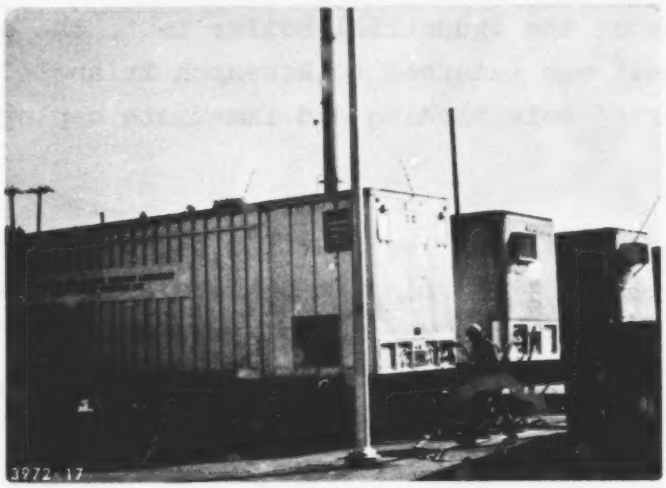

Figure 7. Electrostatic precipitator processing unit - exterior view.

Figure 8. Electrostatic precipitator processing unit - interior view.

Colstrip, Montana Testing

Upon completion of the industrial boiler test, the electrostatic precipitator unit was returned to Research Triangle Park, North Carolina for brief refurbishing and immediate deployment to the field.

As mentioned previously in the Amarillo baghouse test background statement, western coal burning in boilers creates problems for electrostatic precipitator removel of particulates from the stack gas. One technically promising approach to alleviate this problem is the addition of powdered materials to the gas upstream of the precipitator which have the capability to beneficially change precipitator particulate removal efficiency. A western coal burning power plant in Montana was selected to run field tests on the concept.

Delivery of the electrostatic precipitator to the Montana testing site was completed by the end of Mary 1977, and after hookup was accomplished (about two weeks), testing was initiated. This program is ongoing over the reporting period.

MOBILE ENERGY VAN

Background

The EPA Energy Van is an energy research unit designed and constructed by Englehard Industries for the U.S. Environmental Protection Agency. It contains energy supply systems for the home which are designed to be environmentally clean and energy conserving.

Integrated systems include fuel cells, a solar energy collector, a heat pump, and catalytic appliances. These systems provide the energy needed to heat space and water, and to cool, ventilate,

cook, light, operate appliances, and refrigerate within the van. Figures 9 through 11 illustrate the van configurations.

Objectives in building the van were to develop and demonstrate an energy supply system which cuts pollution and energy consumption by as much as 50% for residential and commercial buildings.

This mobile unit was acquired by the contractor on 21 June 1976. A test plan was written for a one year testing program to be conducted at the National Environmental Research Center, Research Triangle Park, North Carolina, in the hope of beginning testing during August of that year. Included in the test plan was a complete safety audit of the unit prior to testing.

The safety audit revealed a number of items judged to be hazardous to operators by the inspection team. In consideration of this judgement, van testing was held in abeyance until a modification plan could be defined and fully implemented. In the interim, a three-week limited operation test was conducted during December 1976, using only the solar panel and associated equipment. During this test period, outside temperatures remained generally below -6.7°C (20°F), yet heat derived from the solar panel and associated thermal energy storage system was sufficient to maintain living area temperature at least as high as 20°C (68°F) except for one period where no direct sunlight was available over a 48-hour period.

A final resolution of the safety modification plan was accomplished in March 1977 and work began on modification. At the end of the operating period covered by this report (30 June 1977) work was still in progress.

Figure 9. Energy van - side view.

Figure 10. Energy van - interior living area.

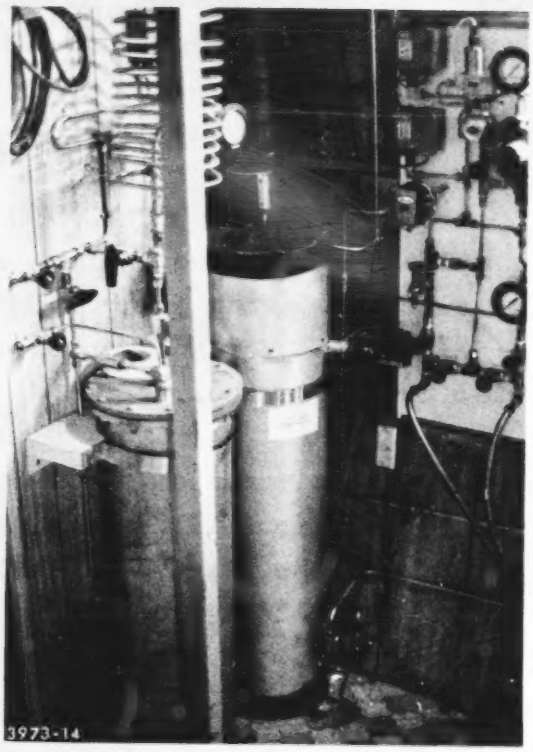

Figure 11. Energy van - fuel delivery system.

SECTION 3

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